On the Notion 'Phonological Rule'[1]

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1. Introduction

Phonological analyses are commonly formalized in terms of derivations, any derivation consisting of a sequence of outputs generated by a train of (partially) ordered rules operating on an abstract underlying shape. The metatheory underpinning such an analysis naturally contains the terms 'rule', 'rule-order', and 'derivation' as unanalyzed primes. There are a number of ways in which one might attempt to justify the introduction of such primes into a theory of phonology.

1.1. Formal criteria.

The first criterion is purely formal. If one constructs a system using such primes, they are justified insofar as they make a workable system and are in fact (experientially) interpretable. Even then, it is to be noted, on the assumption that the relations between at least some of the phonetic representations within paradigms or across morphological derivations are not synchronically random (i.e., suppletive), the adoption of rule-derivations involves a covert claim about human information-processing, viz., that related representations are not simply stored separately, but that use is being made of the systematic regularities found to construct an economical overall system of representations and rules.[2]

1.2. Substantive criteria.

The second kind of justification of primes involves appeals to various kinds of reality outside the system itself, i.e., considers the desired interpretation, at the point of choosing the primes (cf. Hempel 1953). Here fall, first, the problem of psychological reality and the problem of real-time models, for which I give brief examples only; and second, the problem of acquisition, to which the remainder of this paper is devoted.

1.2.1. The psychological reality of allophones and inventory-segments may be demonstrated (e.g.) from slips of the tongue (Fromkin, 1971), from naive syllabifications (Sapir, 1925) or even from Pig-Latin-type childrens' secret languages. In turn, attempts have been made to justify quite abstract underlying representations by appeal to the nativization of loan words (Hyman, 1970), while the possibility of demonstrating the reality of 'levels' of phonology is perhaps illuminated by studies in aphasic speech (e.g., Whitaker, 1971).

1.2.2. The requirement that the language model be one that explicates the real-time processes of speech production or perception is a constraint so far set aside by generative phonologists (as by syntacticians), who have tended to assign to a (usually quite unspecific) model of Performance only such so-called peripheral matters as speed of speech, co-articulation, and the Basis of Articulation (cf. Chomsky and Halle, 1968), together with such (again ill-defined) notions as 'strategies for the use of Competence'.

1.2.3. But it is worth inquiring whether 'possible performance' does not in fact define the content of Competence. In particular, it might be claimed that the neuro-physiological mechanisms available to the child as a beginning language-learner are in fact sufficient to account in a natural way for at least parts of a language sub-system such as phonology, and containing such primes as rule, rule-order, and derivation.[3] This is the argument from acquisition, to which I now turn. However, since some of the kinds of data I shall use may be unfamiliar to linguists, let me begin by briefly outlining my procedure.

I shall first bring analogs from simple natural motor-command systems, for the notions: train of processes, executive command of processes, and reciprocating and reverberating processes. It is in terms of the very special constraints that human language places on the use of these simple elements that an attempt will then be made to show what is uniquely human, and moreover unique in human cognitive processing, about the notions 'ordering or processes' and 'derivation', at least so far as phonology is concerned.

2. Trains of processes.

A major assumption of generative phonology is that the alternative realizations of non-suppletive forms in fact share common (sometimes quite abstract) underlying representations, to which they are separately related by (sometimes quite lengthy) trains of rules or processes. The strongest claim (Cf. 1.2.1 above) about such rule or process-trains would be that, when properly chosen, their contents and order are psychologically real (e.g., can be brought to consciousness by suitable techniques) and that they operate in real time when we speak--though of course this does not mean that all rules correspond to muscle-commands, a question which will be returned to (sec. 4 below).

2.1. Central command of process-trains.

We first seek an analog for trains of processes commanded by individual segments of representations. Such an analog is not hard to find in lower organisms. Thus, in some kinds of arthropod, ordered motor outputs may be released by activity in single central (inter-) neurons. Take for example the control of the postural muscles in the abdomen of the crayfish. On one side of a given abdominal segment, the mutually antagonistic slow extensor and flexor muscles are each supplied with six efferent neurons, five motor and one inhibitory. The flexion command, for instance, then seems to involve not only excitation of the five flexor motoneurons plus the extensor inhibitor, but at the same time inhibition of the five extensor motoneurons plus the peripheral inhibitor to the flexors. The cyclical discharge of the whole reciprocating system, consisting of over 120 efferents, is controlled by the discharge of a single central cell (Kennedy, Evoy, and Hanawalt, 1966).

To generalize this to a phonological rule-series is not difficult, though it may be hazardous: it is possible for a central segmental representation (say, in a single central neuron) to trigger an executive command for a whole train of processes (e.g., a derivation for that segment), locked to the identity of that central neuron.

2.2. The content of process-trains.

Centrally triggered trains of behavior characteristically contain reciprocating and cyclical elements, in addition to simple non-repetitive elements.

A good example of a cyclical reciprocating system is the posture control system in the crayfish described above. For the child's production system, the dominance of reciprocation (e.g., CV-syllable structure), and reverberation (e.g., sequences of identical syllables) is obvious from the structure of babbling and early imitations: the command unit seems to contain the reciprocating syllabic gesture, while the command train seems to consist of repititions of the same complex gesture. We find babbling sequences of the structure [ba-ba-ba] or [da-da-da], but never for example an alternating sequence such as *[bi-ba-bu].

The vowel and consonant harmony of somewhat later child language attest the continued importance of this pattern, whose reflexes are also important in the structure of adult language: we continue to find cyclic processes, both in the simple circumstance of vowel-harmony and at the higher level of integration required for cyclical stress-assignment.

A more complex example, containing both repetitive and non-repetitive elements of behavior under central control, is the pre-skin-shedding activity of the giant silk-moth (Truman and Sokolove, 1972). In response to a signal from a photoreceptor in conjunction with a biological clock, a hormone is produced. This hormone activates a centrally-generated train of behavior lasting well over an hour. Two main periods of activity are defined, each containing a repeating chain of reciprocating movements; first, a period of abdominal twitches, and second a period of peristaltic waves.

Clearly, the information for complex cyclical and reciprocating process trains (say, phonological process trains) may be preplanned in the nervous system, to be run off on receipt of the appropriate neural or endocrinal signal.

3. Mentalized processes in trains.

But the analogs are still quite unsatisfactory in a number of respects. Of most immediate importance here is the fact that, as distinct from the systems referred to, a train of processes applied to a given segment in phonology does not result in a corresponding train of overt motor activity. Rather, only the segment-representations available at the output of the final process can be the basis for signals to the appropriate cranial nerves and thus commands to the speech tract. Leaving aside for the moment the problem of stylistic (including fast-speech) variation, let me illustrate with an unambiguous example: thus, in 'divine' neither the underlying /ī/ nor any intermediate stage, but only the final output /ái/ is responsible for a signal for tongue-movement. The claim remains, that is, that the discharge to the final common command path (the cranial nerves) is under the control of the central neuron representing a particular linguistic segment. But there is a special constraint on the system that scans the space-pattern of the central system for language (Cf. Lashley, 1951); peripheral excitation is suspended until the entire process-train has been scanned.

It would seem of importance to considerations of innateness in language acquisition, that it is difficult to find any analog in the lower systems for precisely this last quality, viz., the constraint 'excite the final output only' (cf. 3.1.1).

3.1. Models and the abduction of order.

In the light of the mechanisms suggested, and of the constraints under which they seem to operate, at least two models suggest themselves to account for the occurrence of ordered processes as a natural product of language-acquisition. Both these models account not only for derivations, but also for the dramatic contrast in control abilities as between babbling, with its inventory of 'all possible sounds', and early speech, with its near-total poverty of inventory. Each corresponds to one of two important ways in which a neural system may be internally modified during maturation, viz., (1) by changes in existing programs due to radical modifications in levels of endogenous excitation, and (2) by the release of new programs as such, though utilizing existing network activity.

3.1.1. Changes in existing programs.

The first model assumes that at the stage when the cortex replaces the brain stem as controller of vocalization (cf. Drachman, 1970), inherent patterns of motor-control are quite suddenly reprimed. As a result, the output system is now inflexible to all but a very narrow range of possibilities: in brief, it can produce only the maximally differentiated reciprocal motor-pattern represented by 'cv', e.g. [pa].

In this model, rule-sequences arise during maturation, as the mental quantifications of what prove to be possible routes to diversified pronunciation. Thus, for example, at the stage when it becomes possible to produce the carefully controlled spirant f, the fact that it was 'easier' before to produce only the ballistically controlled stop p becomes coded as a process converting spirants to stops. Similarly, the greater 'ease' of p than either t or k, and later of t than k become codified as two processes converting, first k to t, and then all t (including t from k) to p. Likewise, the 'easiest' vowel at the earliest stage is that most differentiated from the most closed and minimally controlled stop p, viz., a: diversification of command, with consequent control over the most contrasting vowels i, u, again corresponds to processes laid down. This time the processes convert all vowels to a.

Thus trains of processes are laid down, each process representing, though in obverse, a single quantal jump from a maturationally easier segment to one maturationally more difficult. As command improves, these derivational-trains grow in length. But they also grow in complexity, since each improvement involves a contextual hierarchy of ease, a hierarchy which of course remains a part of the system (Cf. Zwicky 1972 for such hierarchies in adult language). Thus, for example, nasals may appear early in development. But they appear first only word-initially, and there only when all the segments following in the same word allow the velum to remain partly down; the corresponding processes laid down as the nasal is mastered for other positions and environments, will convert nasals to the corresponding consonants lacking the difficult velum lowering, i.e., stops.

It is of course to be expected, given even the present limited understanding of the complex mechanical forces of inertia in the tract, that a segment should depend to a greater or lesser extent on its neighbors. It is also beginning to be clear how the more extensive dependencies seen in child-language vowel and consonant harmony are related to the structure of the control system. But there is a third level of complexity to the problem: within mentalized process-trains, successive processes are seen to prepare segments for each other in both anticipatory and inertial fashion, so that the processes appear to 'hunt' backwards and forwards through a word. Since both local and distant-assimilation processes behave similarly in this respect, a simple example involving 'distant' processes will suffice. Consider the child-form [dog] for 'God'. The derivation involves two processes, each affecting a different segment, and the one must operate before the other; thus, velar assimilation of the second consonant creates the (also found) intermediate form [gog], but subsequent velar dissimilation of the first consonant is required to 'complete' the derivation as [dog].

It thus seems that in the acquisition period we see the natural ontogeny of process-trains; based on the quite elemental mechanisms also found in lower organisms, they show the complexly ordered contextual interactions characteristic of adult phonological systems. As with the 'output' constraint considered above (sec. 3), it is hard to find an analog for this 'hunting' property of language processes, in the control systems of lower organisms.[4]

3.1.2. The release of new programs.

It is clear from the case of the silk-moth described above, that complex process-trains can be pre-planned in the nervous system, to be released as whole programs. It might thus be claimed that just such a set of processes is triggered as a whole program, when control of vocalization is transferred to the context during maturation. The knowledge, by what quantal leaps in ability improved pronunciation will be possible, is here interpreted as a set of 'incompetency rules' (Smith, 1970) or perhaps more appropriately as 'innate processes' available to the child (Stampe, 1969).

3.2. Evaluation of models.

Insofar as it can hardly be a useful function of rules to destroy information as the natural process-train does, the innate processes must be understood not as instructions, but rather as inevitable tendencies in the tract, to be overcome as soon as possible. So far, it is hard to distinguish this from the concept that the improved pronunciation requires improved control, and that the structure of the tract and its command-system dictates the order and hierarchies of improvement.

On the other hand, the notion that processes are 'laid down' would imply that they are not available to inspection in the first place. This makes the funneling function[5] of naturally-ordered processes impossible to apply to the child's first attempts. But it also fails to account for latent learning, i.e., learning which occurs without overt practice on the part of the child; for once we admit that pronunciation difficulties may be overcome in the child's mind, then why should the processes involved not simply be there (in the child's mind) already?[6]

3.3. Acquisition strategies and marked order.

It is already clear that the view of child development held here is hardly mechanical. And in fact, the more difficult concept of 'marked order of processes' can hardly find an explanation without allowing for a quite creative view of the child's development, one which in principle allows for the intervention of developmental strategies.

Let us assume the innate process-train and its (natural) ordering. Then, there can be relief from the catastrophic cumulative consequences of the operation of this process-train only if it can somehow be interrupted. The first type of interruption, Stampe's partial or total suppression of some process, presents no problem here; it corresponds straightforwardly to the notion of command-maturation, and of course implies immediate improvement in the relevant segment in all applicable forms.

But there are at least two other ways in which the child may circumvent the massive homonymy created by his own incompetence; insofar as these resemble 'deliberate' attempts to go beyond systematic ability, it may help to look on them as strategies for the preservation of underlying information. The two strategies I refer to are 'Use whatever temporary mechanisms you can', and 'Replace a vulnerable segment by a less vulnerable one if you can'.

3.3.1. 'Use whatever temporary mechanism you can'.

This strategy in fact generates three kinds of artifact of interest in phonology generally. The simplest of these is that segments may have unusual context-free allophones, as when a child first produces [sok] for both 'shock' and 'sock', and then suddenly disengages š from s by producing [ɬok] and [sok] for the same forms.

More importantly, the result of this allophonic process sometimes appears to mimic a segment not presently pronounceable in its own right. For instance, the Velten child (Velten, 1943) at one stage produced [but] for 'bed', but [dud] for 'train', i.e., the /d/ not pronounceable in 'bed' turns up in place of the (equally unpronounceable) /n/ in 'train'. There is some evidence (Cf. Menyuk and Klatt, 1968; Kornfeld, 1971; and Drachman, 1971) that such derived segments do not always in fact mimic the exact articulation of the impersonated segment, and may thus constitute artifects of the researcher's perception. Now perceptually-confused researchers are also adults in speech communities; it must thus not escape us that this phenomenon strongly resembles what Kiparsky (1971) has called 'opacity', viz., of the type where A, which normally gives B, may nevertheless reappear as the reflex of an underlying C.

Notice also that a sound change can easily arise through such an artifact in the child's perception. Suppose that underlying /d/ and /n/ are both problematic for the child, and he substitutes some pronunciation of /n/ which in fact acoustically resembles /d]. On mastering the nasal, he may very well retain the pronunciation of the impersonating segment, now functioning however as his regular manner of producing (not /n/ but) /d/.

The third and most important artifact of this strategy is that its results may resemble those obtainable by re-ordering naturally-ordered processes, a phenomenon I have discussed elsewhere (Drachman, 1971). Briefly, if at the earliest stage, underlying final p-b-m produce only p, then the processes supposed are the feeding pair (1) m → b, and (2) b → p. Notice that the data explained above as resulting from a perceptually confusing impersonation, could be interpreted (though, as I have suggested, misleadingly) as resulting from the (extrinsic) ordering of the two processes just given.

3.3.2. 'Replace a vulnerable segment if you can'.

The strategy of segment replacement takes us back to a quite elemental mechanism in child speech-production, that of distant assimilation already referred to. While this mechanism operates blindly most of the time, it seems that there are occasions when it is deliberately exploited by the child to preserve information. Sporadic cases occur in the data for a Greek child (Drachman, 1972b), who, for example, produced [lilí] for [kliδí], 'key'. But stop-plus-resonant clusters in other forms of the same corpus always lose the resonant, never the stop; and similarly, intervocalic /δ/ in other forms weakens to [y] and is optionally lost between palatal vowels, but never gives the present [l]. Thus it seems that the child has chosen to preserve a trace of the intervocalic /δ/ by assimilating it to the /l/ of the initial cluster, a 'decision' that entails reducing that cluster in anti-canonical fashion in the first place. This analysis will seem the more plausible if it is noted that by the operation of 'reduction' processes normal for this child, the alternative shape for /kliδí/ would have been the highly degraded [ḱi].[7]

4. Real-time models.

I should like, finally, to return to the question of real-time processes and the distinction between Competence and Performance. As already pointed out above, it is of course absurd to suppose that all the processes operate within the final common path, that from the cranial nerves to the muscles of the vocal tract. Can we, to take the opposite extreme, find any evidence to support a real-time version of the Chomsky-Halle (1968) view of phonology as a seamless web of processes, viz., a version which the processes are in performance distributed along the nervous tract, from the cortex to the neuro-muscular junctions in muscles of the speech tract?[8]

For at least a good many of the processes, the indirect evidence at least does not exclude such an interpretation. I cite evidence of two kinds; that concerning the Basis of Articulation and its relation to the stylistic variations subsumed under the cover-term 'fast speech'; and that from an unusual kind of aphasia.

4.1. The basis of articulation and fast-speech.

Skilled behavior such as speech-production requires priming, that is, the setting up of appropriate ranges of tonus in (neural and) muscle-systems for maximally easeful operation in the relevant language (Drachman, 1972a). In addition to this complex priming system, the model also requires the operation of a threshold device, that is, a device by which fine adjustments are made within the range given by the Basis: this device controls the overall excitability of the system, making it more or less sensitive. I have assumed that the speech-tract control system incorporates such priming and threshold devices, and that these are necessarily programmed by the child during the acquisition process, as he hears the full range of styles (from mumbling, to syllabified dictation of telegrams) acceptable in the dialect he is learning. Both the Basis of Articulation and the threshold device are of course real-time control elements. The former guarantees the range of processes over which the tract will respond with maximal ease, by ensuring that the tract members are strategically placed and shaped; while the latter responds to 'style', and selects the proper place in the hierarchies along which these processes function.

The operation of the 'threshold device' also explains the apparent insertion of a process into a process train, as sometimes occurs in fast speech, as an artifact of the nature of processes. For example (Zwicky, 1972), 'N-loss before t' seems a plausible natural process, in terms of the problem of velum-timing. But for English this is a submerged ice-berg type or process, that is, the Basis of Articulation for English puts an initially high threshold value on it. Only the shifting of the threshold to a lower level, as occurs in fast speech, actually exposes the tip of this iceberg and only thereafter, of course, can intervocalic Flapping occur, so that /winter/ produces [wIɾɚ], in American English.

This kind of evidence, taken together with that for slips of the tongue suggests that at least a large number of processes operate in real time when we speak, including many that could hardly be labelled 'allophonic'.

4.2. Higher level processes and real time.

Most linguists would, however, balk at the proposal that 'higher level' processes have even psychological reality, much less real-time status. Yet the matter is perhaps not quite cut-and-dried. The data for aphasia on the whole support at least a two-level structure for phonology (Whitaker, 1971). But consider the case (ibid) of the aphasiac who typically pronounced derived forms such as degradation and practicality with the same vowels and stressing as in the underived forms degrade and practical. Whatever the interpretation given (and very few data are cited), it seems that distinctly non-surface processes of English are being suspended or mis-applied, and it follows that such processes must thus be accessible during the act of speech.

5. Conclusion

(1) Primes such as 'rule', 'rule-order', and 'derivation' may be justified in that the characteristics of phonological systems which they represent in fact present themselves in a quite natural way during the acquisition process.

(2) From the analogs presented, it is clear that certain fundamental properties of process trains are common to even the most primitive motor-command systems. Two properties distinguish process trains in language: first, the complex contextual sensitivity whereby serial processes hunt across forms, and second, the constraint that only the final output representation is relevant to the motor command system. These properties seem specific not merely to human cognition but to language-processing in particular.

(3) In such process trains, natural order in acquisition produces a Békésy-type funneling effect which accounts for the child's poverty of inventory. But clearly, maturational strategies also play an important role in determining outputs. Insofar as they may produce artifacts resembling 'opacity' and 'marked ordering' of processes, such strategies bear on questions of sound change, as well as on the nature of primes.

(4) There is reason to suspect that many (perhaps all) of the processes in a well-formed phonological derivation operate in real-time and are distributed without clearly marked discontinuities through the neuromuscular system.

(5) Finally, if the primes of phonology are definable at least partly in terms of innate and maturationally inspired mechanisms of performance, it is perhaps timely to re-appraise the commonly-drawn distinction between Competency and Performance.

Footnotes

1. This paper will appear in the Proceedings of the 11th International Congress of Linguists, which was held in Bologna-Florence Aug.-Sept., 1972.

2. At this level of inquiry it might be claimed, for example, that the person desinences for the simple Present and Past tenses of the Modern Greek verb are underlyingly -m, -s, -t for the 1st, 2nd and 3rd persons singular, despite the fact that these consonants are never realized in the case of the 1st and 3rd persons--one says, for 'I want, he wants', thélo, théli, and never *thelom, *thelit. The formal ground for the analysis would then be (a) that the Middle Voice does require these desinences, and (b) that the 'lost' desinences are in fact deleted by a (long-standing) rule of Greek for the deletion of all final consonants save s, n.

3. In this framework, empirical questions can and must be raised concerning the nature and origin even of intrinsic ordering, pace the formal criterion in Chomsky (1965) tacitly adopted in Koutsoudas (1972).

4. Insofar as he assumes that only context-free processes are operative in early acquisition, Jakobson (1968) of course lacks an explanation or even an account of this most important phenomenon.

5. Békésy (1967) was of course describing sensory, not motor inhibition, and to this extent the comparison may be misleading. On the other hand, the analogy itself suggests we consider the alternative view: thus, we might consider whether funneling is due not to active processes but to inhibition processes. In that case, diversification of pronunciation would consist not in suppression of processes but rather of de-inhibition.

6. The present case thus constitutes an interesting example of the conflict between innateness and reductionist views of language acquisition. The evidence here adduced seems to support the innateness view, though only marginally.

7. It is tempting to connect this phenomenon--that is, that individual processes do not always operate blind to their own output--with its analog in adult-phonology analysis, viz., the Derivational Constraint, here seen in very general shape.

8. A rough calculation of the real-time requirement for a Performance model was first offered in Reich (1968). Basing

himself on reasonable (if meager) facts about transmission and synapse-times in interneurons, Reich suggested one could have some 1800 neuron-processes per second: that is, at 9 CV-syllables (or 18 segments) per second, a maximum of 100 processes per segment. So long as one does not require the whole phonological system to apply cyclically to individual segments, there is no objection here to a real-time traversing of the whole system, even assuming that all rules are sequential: after all, no phonological system so far described has contained anything near as many as 100 sequential processes.

Bibliography

Békésy, G. von. 1967. Sensory Inhibition. Princeton.

Chomsky, N. 1965. Aspects of the Theory of Syntax. M.I.T.

__________, and M. Halle. 1968. The Sound Pattern of English. New York.

Drachman, G. 1970. Assumptions about acquisition. Paper read at the December LSA Meeting. See pp. 74-82 in this issue.

__________. 1971. Some strategies in the acquisition of phonology. To appear in the Proceedings of the Urbana Conference on Phonology. Also see pp. 83-98 in this issue.

__________. 1972a. Phonology and the basis of articulation. To appear in Die Sprache. Also see pp. 115-133 in this issue.

__________. 1972b. Generative phonology and child language acquisition. To appear in the Proceedings of the 2nd International Phonology Meeting, Vienna. Also see pp. 146-160 in this issue.

Fromkin, V. 1971. The non-anomalous nature of anomalous utterances. Language 47.1.

Hempel, C. G. 1953. Methods of concept formation in science. International Encyclopedia of Unified Science. Chicago.

Hyman, L. 1970. How concrete is phonology? Language 46.1.

Jakobson, R. 1968. Child language Aphasia and Phonological Universals.

Kennedy, D., W. H. Evoy, and J. T. Hanawalt. 1966. Release of coordinated behavior in crayfish by single central neurons. Science 154.917-9.

Kiparsky, P. 1971. Historical linguistics, in W. Dingwall, ed., A Survey of Linguistic Science.

Koutsoudas, A. 1972. The strict order fallacy. Language 48.1.

Kornfeld, J. 1971. Theoretical issues in child phonology. Papers from the Seventh Regional Meeting of the Chicago Linguistic Society.

Lashley, K. S. 1951. The problem of serial order in behavior. L. A. Jeffress, ed., Cerebral Mechanisms in Behavior. New York.

Menyuk, P., and D. H. Klatt. 1968. Child's production of initial consonant clusters. Quarterly Progress Report 91, M.I.T.

Reich, P. A. 1968. Competence, performance, and relational networks. Linguistic Automation Project Report, Yale University.

Sapir, E. 1925. Sound patterns in language. Language 1.

Smith, N. 1970. The acquisition of phonology: a case study. mimeo. Univ. of London.

Stampe, D. L. 1969. The acquisition of phonetic representations. Papers from the Fifth Regional Meeting of the Chicago Linguistic Society.

Truman, J. W., and P. G. Sokolove. 1972. Silk moth eclosion: hormonal triggering of a centrally programmed pattern of behavior. Science 175.491-3.

Velten, H. V. 1943. The growth of phonemic and lexical patterns in infant language. Language 19.4.

Whitaker, H. 1971. On the Representation of Language in the Human Mind.

Zwicky, A. 1972. Note on a phonological hierarchy in English. in R. Stockwell and R. Macaulay, eds., Linguistic Change and Generative Theory. Indiana.